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## **ELECTRONIC PHOTOGRAPHY**

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## **Abstract**

The main objective of my time spent at the NASA Langley Research Center was to assist in the production of electronic images in the Electronic Photography Lab (EPL). The EPL is a new facility serving the electronic photographic needs of the Langley community.

## **Introduction**

The purpose of the Electronic Photography lab is to provide Langley with access to digital imaging technology. Although the EPL has been in operation for less than one year, almost 1,000 images have been produced. The decision to establish the lab was made after careful determination of the centers needs for electronic photography. The LaRC community requires electronic photography for the production of electronic printing, Web sites, desktop publications, and its increased enhancement capabilities. In addition to general use, other considerations went into the planning of the EPL. For example, electronic photography is much less of a burden on the environment compared to conventional photography. Also, the possibilities of an on-line database and retrieval system could make locating past work more efficient. Finally, information in an electronic image is quantified, making measurements and calculations easier for the researcher.

## **Approach**

One of the main goals of the lab is quality consistency through standardization. Although many steps in producing the master image file require subjectivity, there are rigid protocols throughout. There are three very basic steps in the production of an electronic image; capture, processing, and output.

### **Capture**

An image can be captured by one of three methods. The first, and most common, is film capture. Photographic film, negatives or transparencies, are captured using a high resolution (5000 pixel linear CCD array) film scanner. The Leafscan 45 is capable of scanning film sizes from 35mm to 4x5 inches. The approximate maximum sampling frequency of the scanner is 5000 pixels per inch (ppi) for 35mm, 2500 ppi for 70/120/220mm, and 1200 ppi for 4x5 inch films. The resulting image files generally are between 60 and 105 MB.

The second, and least common, method of image capture in the EPL is reflective material scans. The Epson ES 800C flatbed scanner is used for photographic prints, it has a 400 pixel linear CCD array. Because of the lower resolution, the flatbed is used only when other options have been exhausted.

Scanning films and prints can be very time consuming. The average 6x7 cm film scan takes approximately 30 minutes. Fortunately, electronic capture is also an option. The Kodak DCS460 electronic camera has a 2000 x 3000 pixel CCD area array and the images download easily onto the EPL computers. The camera has successfully been used by the lab to capture images for publications and Langley Web sites. Other advantages of electronic capture are: the complete bypass of chemical processing, instantaneous results, and the economical advantage of lower, long-range material costs. The specific DCS camera used for the above mentioned projects was on loan to the lab while waiting for one on back order. However, when the camera arrived it was found during testing, the CCD array had defective pixels and has since been sent back to the manufacturer. A replacement is expected soon.

### **Processing**

Once the image is in electronic form, the processing stage begins. The final file produced in this phase will be called the "Master Image File" (MF). From this file, any type of desired output is created and the file itself will be of the highest possible quality and image integrity. The

purpose of processing the image is to optimize detail and maintain best possible color and tonal quality.

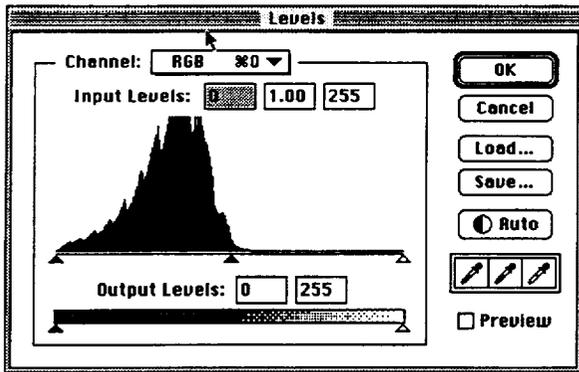


Figure 1 Uncorrected levels.

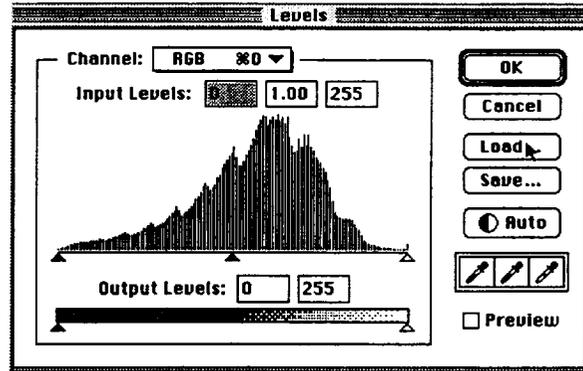


Figure 2 Corrected levels.

The electronic file is brought into the Photoshop 3.0 image processing program, named by its "L number," and the designation that it is a "raw file." The image has 256 levels of grey including pure white and black. These levels, if not already well distributed, are adjusted to maximize tonal range (see Figures 1 and 2). Tonal corrections are always made first because poor tonal distribution can also affect color shifts. The changes in the levels are saved in a separate file and applied to the image. If the image needs further modification in either color or tone, the corrections are made by adjusting the curves.

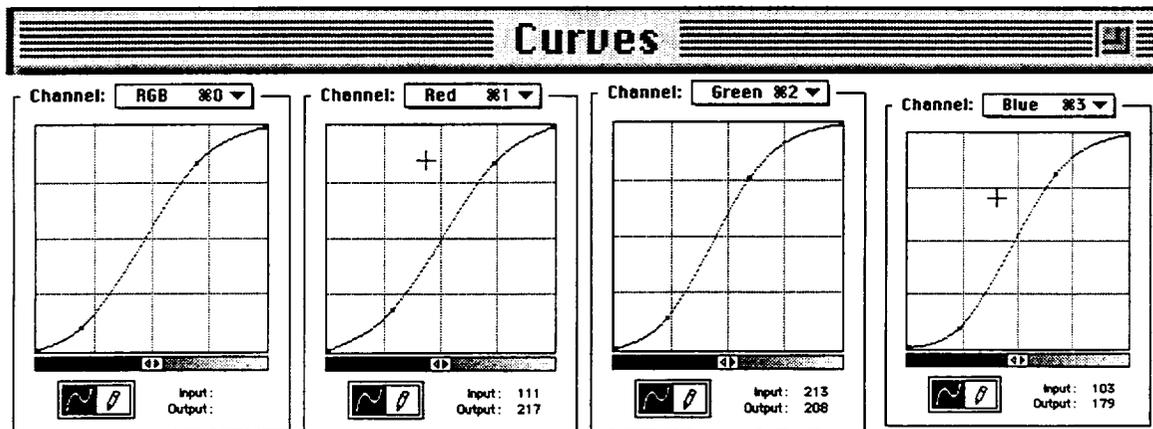


Figure 3 Examples of image curves.

There are four curves for the image, one for each red, green, and blue channel as well as one for the combination of the three (see Figure 3). The combined RGB curve is used to alter contrast, while the individual channel curves are used to compensate for color shifts. Just like in conventional color printing, each channel affects two colors - the color of the channel and its opposite (red/cyan - green/magenta - blue/yellow).



Figure 4 Example image.

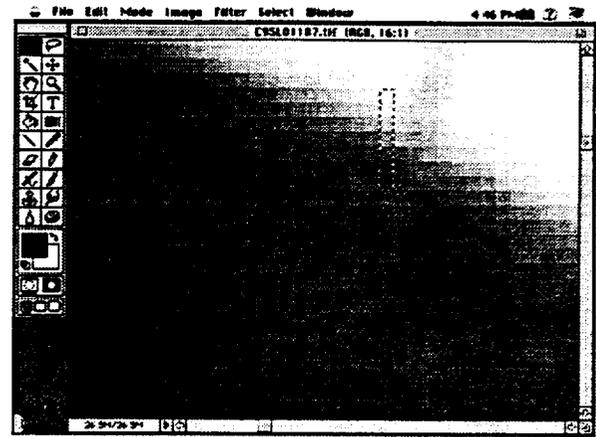


Figure 5 Enlarged area.

Once the image density and color are corrected the MF size is determined. The image file is examined under high magnification of approximately 16:1. An image file will be reduced if an edge transition (from an area of critical focus) spans over five pixels and single grains span over 3 pixels (see Figure 5). Reducing such an image by spatially resampling will not result in significant information loss. Should an image to be reduced be determined as excessively grainy, a median filter is applied before file size reduction. After the file is tone/color corrected and the final file size is applied to the image, a second file is created with the "In Process" designation.

The next step in image processing is to print the electronic file and make final decisions on the tone and color quality. Although the monitors are carefully calibrated, the characteristics of the phosphors change throughout the course of a day. It is also suggested that the human eye is more critical with printed material than with CRT screens. The file is printed on the Fujix Pictography 3000, photographic quality color printer. Currently the Fujix cannot print files larger than 30 MB, so the "in progress" file is reduced to 320 ppi with a width of 4.5 inches. Before the file is sent to the printer, a curve Look-up Table (LUT) is applied to compensate for the density differences between the CRT screens and the Fujix prints. The print is viewed under the MacBeth SpectraLiteII using the three main light sources - incandescent, daylight, and fluorescent. If the image needs further correcting the levels and curves are adjusted and applied to the original raw file and a new "in progress" file is created.

The final, and sometimes most time consuming, step in image processing is the removal of dust and scratches. Spotting is performed on the "in progress" file that has been determined to be of good image quality. Unintended marks are most problematic in film scanned images. In addition to dust and scratches, some of the older negatives have damage to the emulsion such as cracking and mold. The spots are removed by copying a similar part of the image over the blemish. At this point the file is saved as a master image file and permanently stored on CD. From this master file the original requesters output, and any other future output, is made.

### Output

The most common uses for electronic files have been halftone images, Fujix prints & transparencies, TIFF files for documents, and monitor files for Web pages. Another option in the EPL includes film negatives and transparencies from the Solitaire Image Recorder. The Solitaire writes the image to film, either negatives or transparencies, and will accept film sizes of 35mm and 4x5 inches. All these different outputs can be created from the same master image file by simply applying a curve to compensate for the output device. A curve can also be applied to the master image file for quality output on almost any device that can be calibrated.

## Equipment

The Electronic Photography Lab has five workstations. Three stations are designed for image processing, one is designated for printing, and the last is used to write electronic images to photographic film. The stations are labeled by names of colors for ease of identification.

### “Magenta” - Scanning/Image Processing

- Power Macintosh 8100/80 (264 MB RAM/ 250MB Hard Drive)
- Apple 19” multi-scan color monitor
- Andataco 2.3 GB external hard drive
- PLI 1.3 GB 5.25” Magneto Optical drive
- Tahoe 128 MB 3.5” Magneto Optical drive
- Leafscan 45 film scanner (35mm -> 4x5 inch formats)
- APC Smart UPS 1250 battery back-up/surge protector

### “Cyan” - Image Processing/CD Writer Output

- Power Macintosh 8100/80 (264 MB RAM/ 250MB Hard Drive)
- Apple 19” multi-scan color monitor
- Andataco 2.3 GB external hard drive
- Tahoe 128 MB 3.5” Magneto Optical drive
- PLI 1.3 GB 5.25” Magneto Optical drive
- Pinnacle Micro CD writer
- APC Smart UPS 1250 battery back-up/surge protector

### “Yellow” - Image Processing/Print Scanning

- Power Macintosh 8100/80 (264 MB RAM/ 250MB Hard Drive)
- Apple 19” multi-scan color monitor
- Andataco 2.3 GB external hard drive
- Tahoe 128 MB 3.5” Magneto Optical drive
- PLI 1.3 GB 5.25” Magneto Optical drive
- Epson ES 800C flatbed color scanner
- APC Smart UPS 1250 battery back-up/surge protector

### “Blue” - Image Output

- Macintosh Centris 650 (136 MB RAM 80MB hard drive)
- Apple 13” multi-scan color monitor
- APS 730 MB external hard drive
- Tahoe 230 MB 3.5” Magneto Optical drive
- PLI 1.3 GB 5.25” Magneto Optical drive
- APC Smart UPS 1250 battery back-up/surge protector
- Fujix Pictography 3000 printer

### “Red” - Image Output

- Macintosh Centris 650 (136 MB RAM 80MB hard drive)
- Apple 13” multi-scan color monitor
- Andataco 2.3 GB external hard drive
- Tahoe 230 MB 3.5” Magneto Optical drive
- APC Smart UPS 1250 battery back-up/surge protector
- Solitaire Image Recorder film writer

### Server

- MacIntosh IIfx
- 2.3 GB external hard drive

### “Grey” - Electronic Photography Support/Word Processing

- MacIntosh PowerBook 540c (36 MB RAM 500 MB hard drive)
- MicroSystems PCMCIA drive

With the exception of the server, all the computers are equipped with Adobe Photoshop version 3.0 for image retrieval, processing, and output. AppleShare is used to connect the EPL computers to the server and the Langley community. Mathematica was used to create the curves applied to files for output, it is not used on a daily basis.

### Conclusion

The EPL meets its goal of “supporting the acquisition, analysis, documentation, and communication of research by providing direct digital image capture; image scanning, processing, and enhancement; and optimized device dependent imaging protocols for output.” The personnel and equipment in the lab will be forever-changing with technology in order to fulfill this mission.